

**University of Puerto Rico  
Río Piedras Campus  
College of Natural Sciences  
Department of Mathematics**

**Course Syllabus  
Second semester, academic year 2020-21**

## **Course information**

Course title: Optimization

Course code: MATE 6882

Credits/hours: 3 credits/45 hours

Course prerequisites: MATE 5201 (Advanced Calculus) and knowledge of a high level programming language

*Online course due to the COVID-19 emergency*

Room: Virtual classroom via Google Meet, code: bsx-kcsz-owv

Time: Monday and Wednesday 4:00-5:20 pm

Course webpage: [Moodle site](#)

Instructor: Mariano Marcano

Office: Virtual room via Google Meet, code: fvx-swpc-dio

Email address : [mariano.marcano@upr.edu](mailto:mariano.marcano@upr.edu)

Office hours: Monday 11:00 am -1:00 pm and Wednesday 1:00-2:00 pm

Professor's webpage: [epsilon.uprrp.edu/mmarcano](http://epsilon.uprrp.edu/mmarcano)

## **Course description**

This is a course on nonlinear optimization problems, both unconstrained and constrained. We will study optimality conditions and the basic numerical optimization methods with their convergence analysis. The numerical methods include: basic descent methods, conjugate direction methods, quasi-Newton algorithms, reduced gradient method, gradient projection method, penalty and barrier methods, duality, and Lagrange methods.

## **Course objectives**

After completing the course students will know how to:

1. verify the optimality conditions for nonlinear optimization problems, both constrained and unconstrained;
2. apply basic numerical optimization methods;
3. evaluate the advantage and disadvantage of the basic optimization methods;

4. solve large size optimization problems by using the computer;
5. verify the convergence criteria of the basic optimization methods.

## Content outline and schedule

Topic	Time
1. Optimality conditions for unconstrained problems.	3 hours
2. Convexity.	1.5 hour
3. Basic descent methods:	6 hours
(a) line search (1.5 hour);	
(b) steepest descent (3 hours);	
(c) and Newton's method (1.5 hour).	
4. Conjugate direction methods.	6 hours
5. Quasi-Newton methods:	6 hours
(a) the modified Newton's method (1.5 hour);	
(b) methods that construct the inverse of the Hessian matrix (1.5 hour);	
(c) the Davidon-Fletcher-Powell method (1.5 hour);	
(d) and the Broyden family of methods (1.5 hour).	
6. Algorithms for Nonlinear Least-Squares Problems	1.5 hour
7. Take-home exam I (Wednesday, March 24)	
8. Global optimization:	6 hours
(a) Monte Carlo (1.5 hour);	
(b) metropolis algorithm and simulated annealing (3 hours);	
(c) and genetic algorithms (1.5 hour).	
9. Optimality conditions for constrained problems with equality and inequality.	6 hours
10. Primal methods.	3 hours
11. Penalty and barrier methods.	3 hours
12. Trust-region methods.	3 hours
13. Take-home exam II (Monday, May 10)	
Total:	45 hours

## Instructional strategies

- The course will be taught online. The content of the course and supporting materials will be available to the student through the Moodle platform. The lecture notes will be in slide presentations. Video conferences will be conducted by Google Meet at the time of the course to discuss the class topics. To enter the video conference use

the code: bsx-kcsz-owv.

- Assignments will be uploaded to Moodle in pdf format, the students will download the files and, before the deadline, the students must upload the answers to Moodle in a single file. Grading and feedback will be available in Moodle to the student.
- A frequent asked question FAQ Moodle forum will be available to post any question the student may have and answer questions posted by classmates. One point bonus (maximum two points) will be added to the corresponding homework of any student that answers completely and correctly a question of the forum.
- As alternative methods that do not require the physical presence of the students and the teacher in the classroom, we will use: discussion forums, recorded lectures, and video conferences.

## Available and required learning resources

To take advantage of the course material and other resources in Moodle the student needs a personal computer with fast internet access, a PDF viewer, an internet browser, a word processor ( $\text{\LaTeX}$  is free and suitable for writing mathematical expressions), and the high level programming platform MATLAB<sup>®</sup>/Octave. Octave is free and can be downloaded from the [GNU Octave site](#).

## Course evaluation

Evaluation of student understanding of the class material will be made by means of homework assignments and take-home exams. The grade will be computed as follows:

Assignments	40%
Exam 1	30%
Exam 2	30%
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	100%

Assignments will be posted in Moodle at least one week before the deadline.

## Grading system

Letter system ( A, B, C, D or F ).

## Law 51: Rights of Students with Disabilities

Students with access to Vocational Rehabilitation Services should contact the professor at the beginning of the semester in order to plan any special arrangements and equipment necessary in accordance with the recommendations of the Office of Student with

Disabilities (OSEI). In addition, any students with special needs or who require any type of assistance or special arrangements should contact the professor.

## **Academic Integrity**

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Students General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person answers to the questions of an oral or written exam by taking or getting someone else to take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure laid down in the UPR Students General Bylaws.

## **Normativeness on discrimination by sex and gender in sexual violence form**

The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification Num. 130, 2014-2015 from the Board of Governors, any student subjected to acts constituting sexual harassment, must come to the Office of the Student Ombudsperson, the Office of the Dean of Students, and/or the Coordinator of the Office of Compliance with Title IX for an orientation and/or a formal complaint.

## **Bibliography**

**Textbook:** David G. Luenberger and Yinyu Ye. *Linear and Nonlinear Programming (International Series in Operations Research & Management Science)*. Third Edition, Springer, 2008. ISBN 978-0-387-74503-9

### **References:**

1. Mokhtar S. Bazaraa, Hanif D. Sherali, and C. M. Shetty, *Nonlinear Programming: Theory and Algorithms*, Second Edition, John Wiley & Sons, New York 1993.
2. John E. Dennis and Robert B. Schnabel, *Numerical Methods for Unconstrained Optimization and Nonlinear Equations*, SIAM, Philadelphia, 1996.
3. Anthony V. Fiacco and Garth P. McCormick, *Nonlinear Programming: Sequential Unconstrained Minimization Techniques*, SIAM. Philadelphia, 1990.

4. Phillip E. Gill, Walter Murray, and Margaret H. Wright, *Practical Optimization*, Academic Press, New York, 1989.
5. Olvi L. Mangasarian, *Nonlinear Programming*, SIAM, Philadelphia, 1994.
6. Michalewicz, Z. *Genetic Algorithms + Data Structures = Evolution Programs*. Third Edition, Springer-Verlag, New York, 1997.
7. A. Neumaier, Complete Search in Continuous Global Optimization and Constraint Satisfaction, in: *Acta Numerica* (A. Iserles, ed.), Cambridge University Press, 271-369, 2004.
8. Jorge Nocedal and Stephen J. Wright. *Numerical optimization*. Springer, 1999.
9. Peter Salamon, Paolo Sibani, and Richard Frost. *Facts, Conjectures, and Improvements for Simulated Annealing*. SIAM, 2002.

**Electronic references:**

1. M. Marcano, *Introduction to MATLAB*, [preprint](#), 2007.
2. Negrón, P. V., *Un Vistazo a MATLAB*, [preprint](#), 2006.
3. I. Rubio, *CCOM introduction to LATEX*, [preprint](#), 2019.